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ONTARIO WATER RESOURCES COMMISSION

REPORT

on

WATER QUALITY

in

CHEMUNG LAKE

1971

RECREATIONAL LAKES PROGRAM

BBDj

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SUMMARY

A study to evaluate the status of water-quality in Chemung Lake was carried out during the summer of 1971.

Chemung Lake lies in two physiographic regions known as the Peterborough Drumlin Field and the Dummer Moraines. Both regions are characterized by rolling topography, limestone bedrock and soil derived from stony, loam glacial till. Generally, the soil cover throughout the area is less than the five feet required by the Ministry of the Environment for the installation of septic tank systems.

Relatively uniform temperatures, with respect to depth, were observed throughout the year in Chemung Lake. Occasionally, low deep-water dissolved oxygen concentrations and high carbon dioxide levels resulting from decomposition of organic matter, biological respiration and chemical oxidation were observed.

Total alkalinity, hardness and conductivity values indicated that moderately h ard water conditions prevailed in the lake.

The enriched nature of the lake was revealed by moderately high mean concentrations of total Kjeldahl nitrogen (0.55 mg/l) and total phosphorus (0.028 mg/l), two nutrients critical for aquatic plant and algae growth.

Algal levels as measured by chlorophyll a concentrations were moderately high during August and September.

In view of the high nutrient concentrations and moderately high chlorophyll a levels, every effort should be made to prevent any direct

flow or leachate from domestic waste disposal systems or other potential sources of pollution from gaining access to the lake.

Chemung Lake was generally well within the bacteriological criteria for total body contact recreational use during all three surveys. However, in June there was an elevated Fecal Streptococcus level over the central portion of the lake which exceeded the OWRC criteria and Total Coliform counts increased considerably after the June 25 rainfall.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw or other inadequately treated wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface

water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Chemung Lake in the summer of 1971. This study included the assessment of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Physical, chemical and biological surveys were conducted eleven times during the summer of 1971.

Three bacteriological surveys were conducted; a spring survey from June 24 to 28, a mid-summer survey from August 6 to 16 and a fall survey from September 16 to 20 inclusive. Sampling each day for a minimum of five days is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

The "Kawartha Lakes Water Management Study" was also initiated in 1971 to examine the complex problems of eutrophication which exist in the Kawartha Lakes including Chemung Lake. The broad objective of this study is to develop a water management plan to protect and develop the recreational potential of the watershed. Included in this study are programs to evaluate the trophic status of the lakes, the sources of nutrients to the lakes, the nutrient cycling system within the lakes and the specific effects on the water environment of various wastewater inputs. An experiment is also planned to evaluate weed harvesting, both as a method of enhancing the recreational use of a lake and of providing a nutrient drain that could significantly reduce the quantity of nutrients available for plant growth in the future. Along with this experiment, effects of weed harvesting on the sport fisheries is being evaluated by the biologists of the Department of Lands and Forests (now within the Ministry of Natural Resources). The study is expected to continue for at least three years and some data from the first year are included in this report.

A joint federal-provincial study committee (CORTS) has recently released a report entitled "The Rideau-Trent-Severn - Yesterday Today Tomorrow" which considers optimum recreational development of the Rideau-Trent-Severn waterway corridor which includes part of the Kawartha Lakes. Water and other environmental pollution problems received the highest priority in the list of recommendations in this report which was started in 1967. Other recommendations were made dealing with the use of open space, historical preservation

and interpretation, public use areas and other topics designed to develop the corridor as a recreation resource. Many of the recommendations of this report have already been implemented by various federal and provincial agencies such as nutrient budget studies and correction of industrial waste discharges to the waterway.

Geography and Topography

Chemung Lake is located in the townships of Ennismore and Smith in Peterborough County, with the exception of the extreme southwestern end of the lake which is in Emily Township in Victoria County. The lake is approximately five kilometers (3 miles) northwest of Peterborough and forms the western boundary of the hamlets of Bridgenorth and Chemung Park.

The lake lies in two physiographic regions which are divided by a line running east to west between Harrington Narrows and Reserve Island (Figure 1). The Peterborough Drumlin Field lies south of the line and the Dummer Moraines lie to the north. The Peterborough Drumlin Field is characterized by rolling terrain (drumlins and eskers) and Trenton limestone bedrock. The soil type is of the Otonabee Series, a member of the Brown Forest Group, whose parent material consists of a sandy loam textured glacial till containing a moderate amount of stone. Although the depth of till varies locally with a gradual increase from north to south, the soil cover is generally less than the five feet required by the Ministry of the Environment for the installation of septic tank systems.

The Dummer Moraines are characterized by shallow till overlying Black River limestone bedrock. The soil is of the Dummer Series which is also a member of the Brown Forest Group but differs from the Otonabee Series in that the parent materials are very stony loam till. The deeper soil areas have moderate to steep sloping hills, while the shallow soil areas have undulating land with numerous slabs of jutting bedrock. As with the Otonabee Series the soil cover is generally less than the five feet required by the Ministry of the Environment for the installation of septic tank systems.

The shoreline is generally gradual to steep sloping with most areas immediately behind the shore being cleared of trees. The forested areas are primarily at the northern end and are mainly deciduous with sugar maple trees predominating.

Chemung Lake lies in a preglacial valley which formerly drained towards the southwest and was somewhat deepened by glacial action. During the retreat of the glaciers, morainal debris was deposited at the south end of the valley blocking the old drainage pattern and creating a long and narrow lake presently known as Chemung Lake. The lake level was artifically raised by construction of the Trent Canal System and its numerous dams.

The lake is approximately 24 kilometers (15 miles) long and has an average width of 1.3 kilometers (0.8 miles). The shoreline has few irregularities and is 66 kilometers (41 miles) long. The lake has a water surface area of 25 square kilometers (10 square miles) with a maximum depth of 7 meters (23 feet). Aquatic vegetation is abundant throughout the entire lake.

Climate Range

The Kawartha Lakes region has colder winters and later springs than those regions lying closer to the moderating effects of the Great Lakes. The mean annual temperature is 6°C (43°F) while the winter and summer mean temperatures are -8.0°C (18°F) and 19°C (66°F) respectively. The annual precipitation ranges from 67 centimeters (26 inches) to 86 centimeters (40 inches) including 200 centimeters (80 inches) of snow. According to meteorological records the area enjoys about 240 days with no measurable precipitation. The summer climate is conducive to most

recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

Chemung Lake is part of the Trent Canal System and lies in the Bay of Quinte Terminal Drainage Basin. The lake has four small inlets, three in the south end and one in the north, all of which have low flows and drain agricultural land. The only outlet is at Harrington Narrows which empties into Buckhorn Lake.

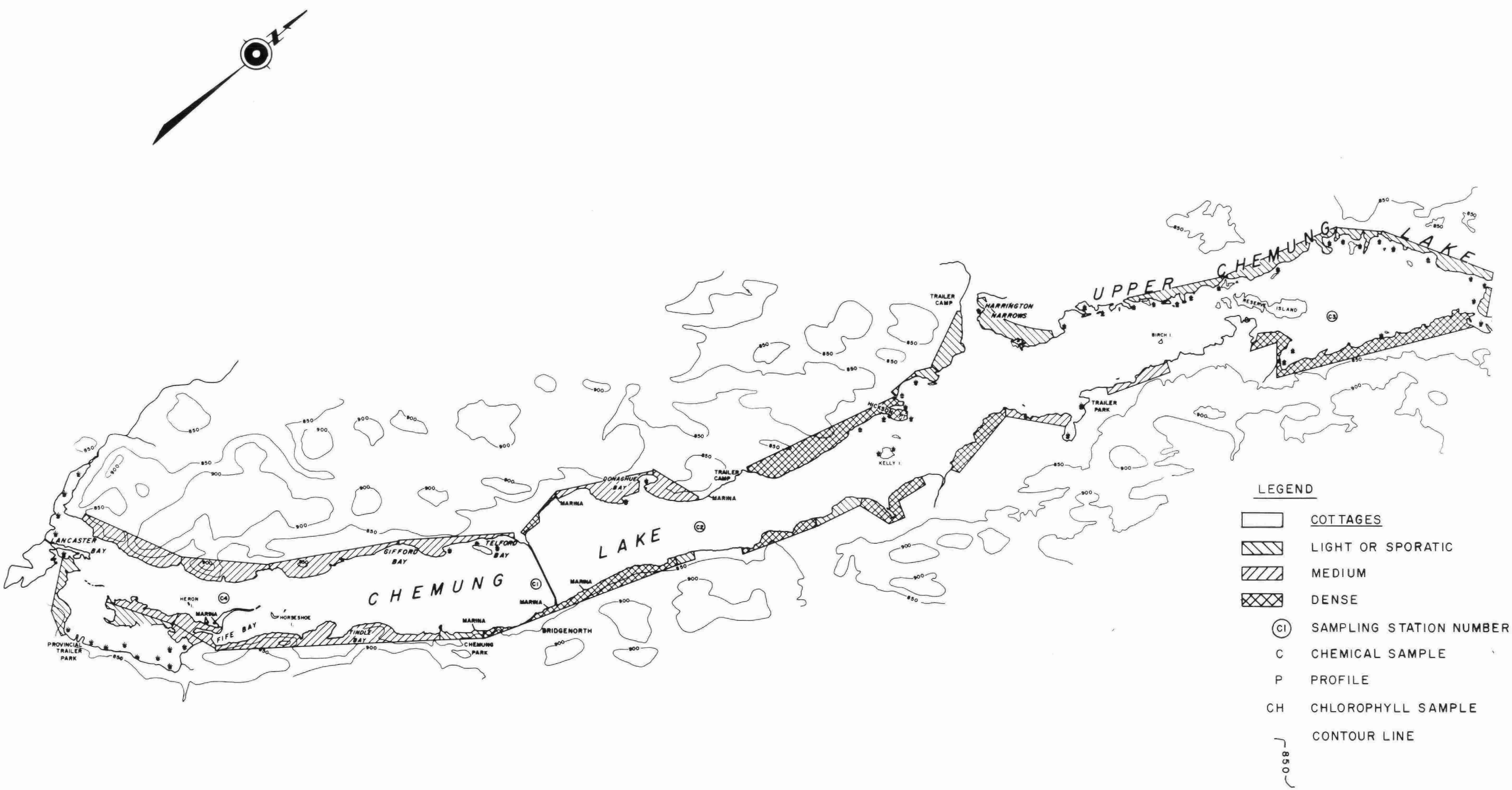
Shoreline Development

Chemung Lake has a heavily-developed shoreline with approximately 890 cottages situated continuously along it with the exception of a few local areas such as the Curve Lake Indian Reserve. The appended map (Figure 1) shows the relative densities of the cottage areas. The hamlets of Bridgenorth and Chemung Park are located along the west-central shore near the causeway. The causeway is a solid structure with a narrow bridge near the east end.

Water Usage

Although there are a few private wells for the permanent homes on Chemung Lake, most of the cottagers use the lake water as their source of domestic water supply. The lake is mainly used for recreational purposes such as angling, swimming and boating. According to the information available from the Department of Lands and Forests the common fish in the lake are maskinonge, smallmouth and largemouth bass, walleye, catfish, carp, pumpkinseed, yellow perch, rock bass and white suckers. Chemung Lake is part of the Trent Canal System and according to the Department of Tourism and

CHEMUNG LAKE
FIGURE –



ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

CHEMUNG LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN	
DRAWN BY: R.S.	DATE: APRIL 1972
CHECKED BY: A.M.	DRAWING Nº: 72-32-D.E. B

Information, 18,516 boats used the system in 1969. Boaters spent an estimated $8.6 million and an additional $3.6 million was spent by the Federal Department of Transport for operation, maintenance and capital expenditure. Thus, $12.2 million was injected into the economy of those areas adjacent to the Trent Canal in 1969.

Previous OWRC surveys of the hamlets of Bridgenorth and Chemung Park did not reveal any significant direct waste discharges to the lake. Reports of the local Health Unit, however, indicate that numerous problems with the operation of septic tank systems have occurred as a result of small building lots and a prevalent high ground water table.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

In selecting the physical, chemical and biological sampling sites on Chemung Lake an endeavour was made to choose the deepest location. As well, a sufficient number of additional stations were sampled to represent adequately the entire lake (Figure 1).

Temperature profiles were determined at each station using a telethermometer. Dissolved oxygen levels were measured using the alkaline azide modification of the Winkler method (Standard Methods 13th Edition). Additionally, samples for pH, total alkalinity and free carbon dioxide were collected 1m below the surface and 1m above bottom using a Van Dorn water sampler. The total alkalinity and free carbon dioxide concentrations were determined titrimetrically at the mobile laboratory located at Trent University, Peterborough.

At each station, two 32-ounce samples were collected using a composite sampler lowered through the euphotic zone (2x Secchi disc) or to 1m above bottom, whichever was less. One sample, for chlorophyll analysis, was immediately preserved with 10-15 drops of a 2% $MgCO_3$ suspension. The second sample was divided into two sub-samples; the first sub-sample was frozen for phosphorus and nitrogen analyses, and the second was refrigerated and subsequently analyzed for iron and hardness. In addition, when the euphotic zone did not extend to the bottom, samples were collected from 1m above the sediment using a Van Dorn sampler and submitted for phosphorus, nitrogen, iron and hardness analyses.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus concentrations were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths from 600 to 750 mμ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Two five-day intensive bacteriological surveys were completed in June and September, and one eleven-day survey was completed in August on Chemung Lake. In June and August, 43 samples were taken daily, including three depths samples at Stations 14D, 22D and 36D. In September, 36 samples were taken daily, including depth samples at Stations 14D and 36D. The following Stations; 2, 3, 9, 13, 22, 22D, 30 and 51 were not sampled sampled in September due to a shortage of laboratory personnel.

Surface samples were collected at a depth one meter below the surface using sterile, autoclavable, polycarbonate 250 ml bottles. Depth samples were collected one meter above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes.

All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration (MF) technique (Standard Methods 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. The "indicators" are normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing microorganisms may also be present.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on a lake can be grouped, by this method, into areas or groups of stations within the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with only slight differences in bacterial concentration can be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analysis of variance program (ANOVA-CRE; Burger, 1972) was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the *Escherichia coli* group, closely related bacteria of the genera *Citrobacter* and *Enterobacter*. The *Enterobacter* - *Citrobacter* groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the *Escherichia* group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for *Escherichia coli*, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Both of these assumptions were checked on Chemung Lake. The Bartlett's test was found to be non-significant and the data followed a normal distribution, hence the analysis of variance (F-test, Sokal, 1969) was calculated on all stations.

If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the June, August and September surveys.

Temperature and Dissolved Oxygen

Four profile stations were established on Chemung Lake: two (C-1 and C-3) were located in deep water with no adjacent weed growth while the remaining two (C-2 and C-4) were located in dense growths of aquatic macrophytes.

Thermal stratification or temperature zonation with depth was not observed in Chemung Lake. Temperature differences between the surface and bottom strata were generally less than 1°C throughout the study (Figure 2) indicating the effect of vertical mixing processes. Surface water temperature was highest (23.5°C) on August 9 at Station C-3. During the latter part of August, air temperatures as low as 14.7°C were instrumental in reducing water temperatures to 17.6°C.

In general complete vertical mixing of the water was evident throughout the study, as oxygen concentrations rarely varied by more than 3% saturation between the surface and bottom waters (Figures 2b, c and d). At Station C-3 on July 1, the dissolved oxygen reached 28% saturation 1m above bottom. A plausible explanation for this low oxygen level is that the station is located in a confined basin at the north end of the lake where wind action would be less effective in mixing the water than in the main lake. This deep-water oxygen deficit results from bacterial oxidation of organic matter, biological respiration and chemical oxidation.

pH, Total Alkalinity, Hardness, Free Carbon Dioxide and Conductivity

In general, pH between the surface and bottom varied by no more than 0.2 units, and showed only minor fluctuations throughout the season. The average for the lake was calculated as 8.0 pH units.

FIGURE 2a

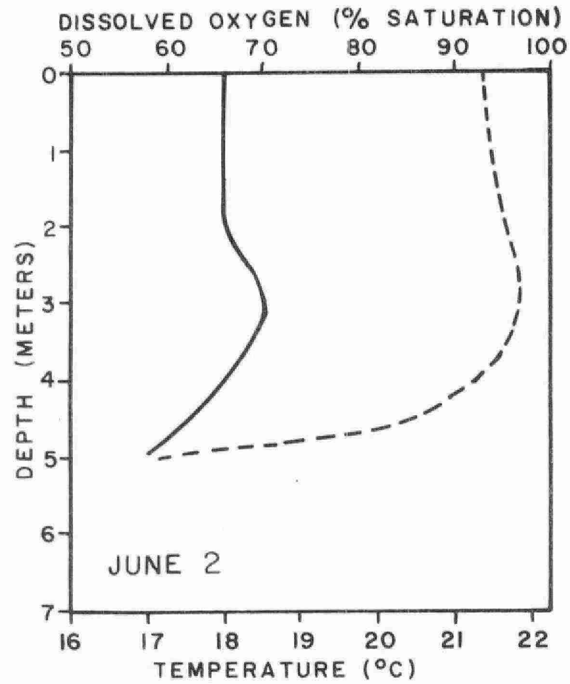


FIGURE 2b

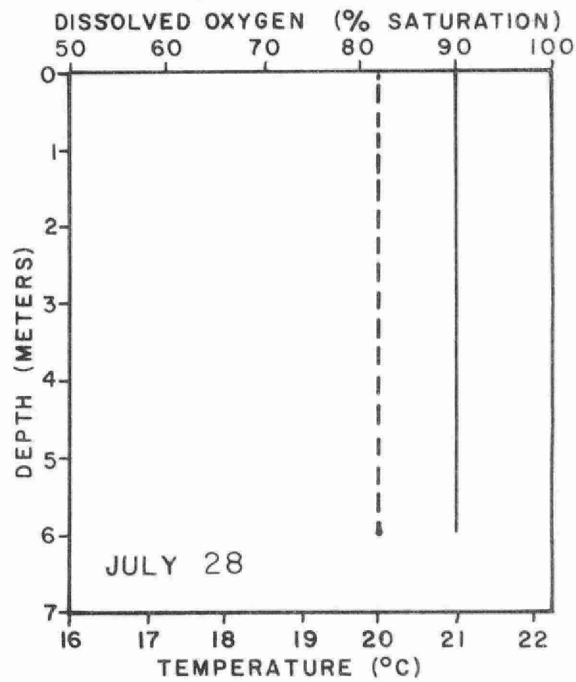


FIGURE 2c

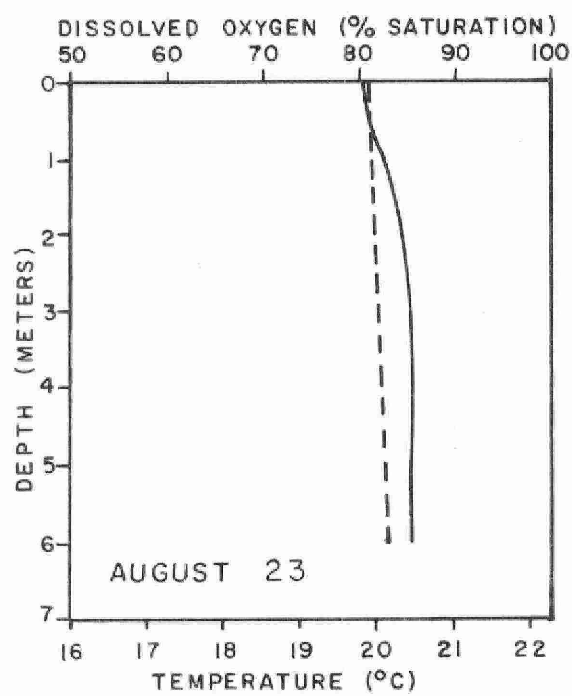


FIGURE 2d

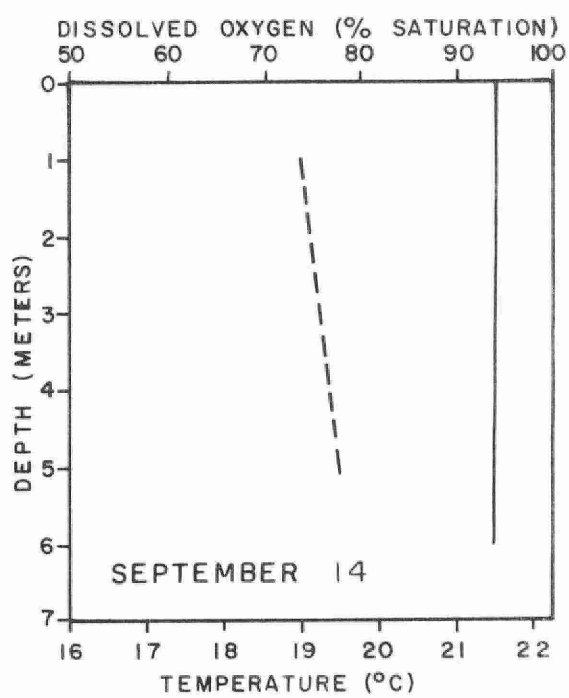


FIGURE: 2 DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR STATION C-1 IN CHEMUNG LAKE DURING 1971.

——— TEMPERATURE
- - - - - - DISSOLVED OXYGEN

Total alkalinity and hardness tended to be highest during the warmest periods of June, July and August; values ranged from 115 to 159 mg/l and 134 to 172 mg/l for alkalinity and hardness respectively (Tables 1 and 2). These values are indicative of moderately hard water quality conditions.

Generally, very low carbon dioxide levels (0.0 - 3.8 mg/l) were obtained. However, at Station C-3, concentrations were as high as 10.0 mg/l in the deeper strata during June, July and August. In relation to the large number of aquatic macrophytes near Station C-4, the relatively high carbon dioxide levels recorded during September may be attributed to the death and subsequent decay of weeds in this area. Additionally, heavy encrustations of marl undoubtedly induced death of the plants.

The lake was characterized by very high conductivity readings which reached a maximum of 490 μmhos/cm^3 and averaged 332 μmhos/cm^3. Surface and bottom values differed by less than 10 μmhos/cm^3 in most cases.

Iron

Chemung Lake produced a maximum iron concentration of 0.20 mg/l but, in general, exhibited levels of 0.05 mg/l or less at all depths and all stations.

Chlorophyll a

Algal levels as reflected by chlorophyll a were in the low to moderate range during May (2.3 to 4.6 μg/l) and June (0.5 to 6.1 μg/l). Moderately high algal populations occurred during July, August and September when values ranged from 3.1 to 9.8 μg/l, 4.1 to 11 μg/l and 3.0 to 9.5 μg/l respectively. The highest concentration of 11 μg/l was present at C-2.

FIGURE 3

CHLOROPHYLL a - SECCHI DISC RELATIONSHIP

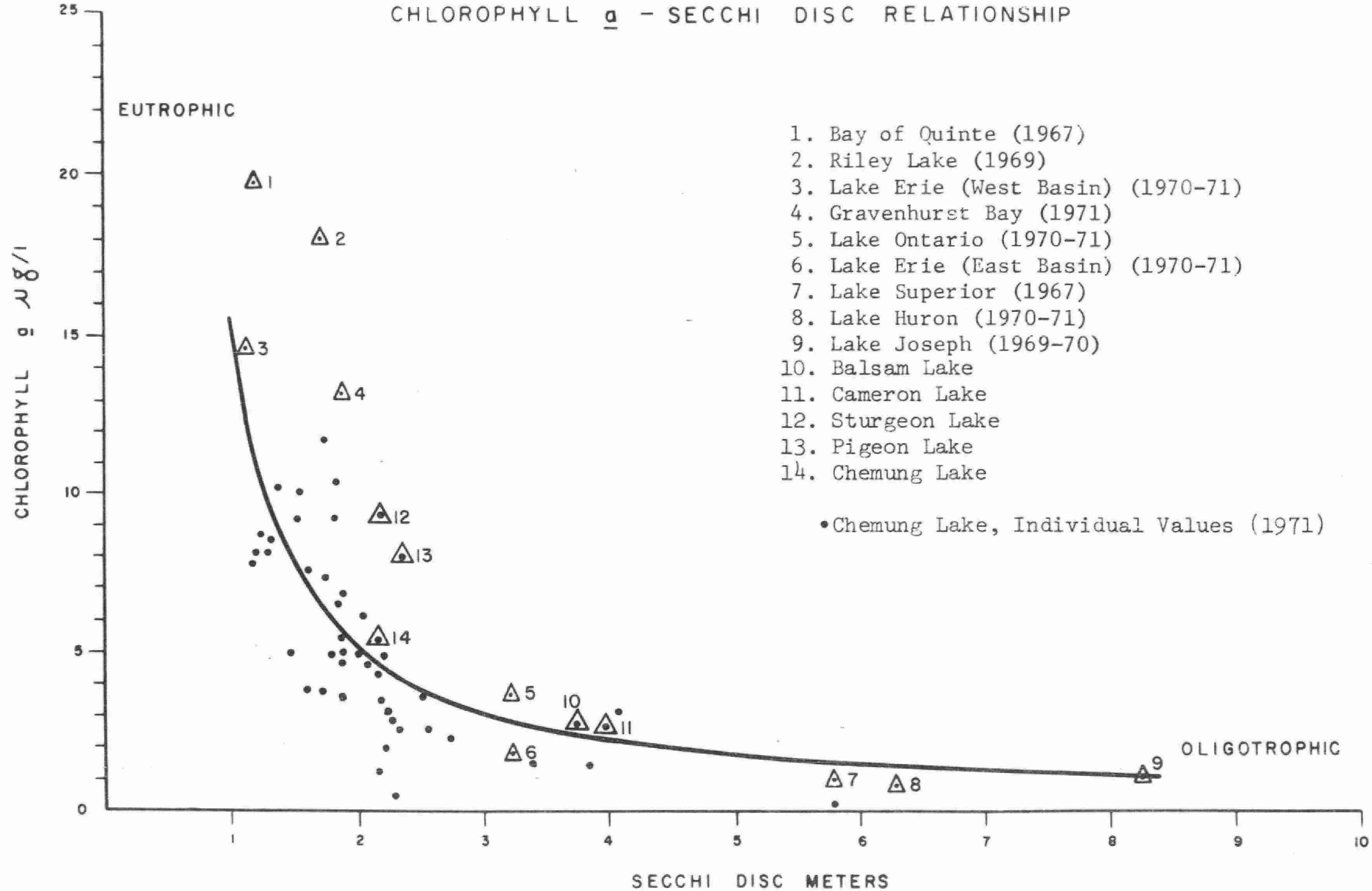


Figure 3: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971, as well as the individual chlorophyll a - Secchi disc values for Chemung Lake. The Great Lakes values were added for comparative purposes.

Water clarity, which is one of the more important parameters used in defining water quality, can be measured using a Secchi disc. Figure 3 presents a chlorophyll a - Secchi disc relationship for a number of surface waters and clarifies the "Trophic status" of Chemung Lake relative to numerous other well known recreational lakes in the Province(see Brown 1972 for derivation of chlorophyll a - Secchi disc relationship). The enriched nature of Chemung Lake is reflected by its position between eutrophic Gravenhurst Bay and the Bay of Quinte, and the oligotrophic to mesotrophic Lake Ontario and Eastern Basin of Lake Erie (Figure 3).

Total Kjeladhl Nitrogen and Total Phosphorus

Total Kjeldahl nitrogen (as mg/l N) in the euphotic zone ranged from 0.35 mg/l to 1.00 mg/l and total phosphorus (as mg/l P) were in the range of 0.012 mg/l to 0.089 mg/l for phosphorus. A pattern was not apparent between euphotic zone and bottom concentrations for these nutrients. However, occasional elevated nitrogen levels, as high as 1.1 mg/l, at near-bottom locations indicated that the bottom sediments were probably being disturbed as a result of wind action. Distinct differences in nutrient concentrations were not detected between stations supporting dense weed growths and those devoid of aquatic macrophytes. Experiments are currently being conducted by the Ministry of the Environment (formerly the OWRC) to determine whether the major portion of nutrient uptake for weed growth occurs from the water or sediments.

Generally troublesome levels of algae appear when total phosphorus concentrations approximating 0.020 mg/l are attained. The mean value of 0.028 mg/l for total phosphorus exceeded this value indicating that

excessive aquatic plant and algae growths will materialize in Chemung Lake. As the lake is for the most part naturally enriched (Schenk, 1971), further inputs from agricultural runoff, inflowing streams and from malfunctioning or improperly installed domestic waste disposal systems will serve to accelerate the process of eutrophication.

Bacteriology

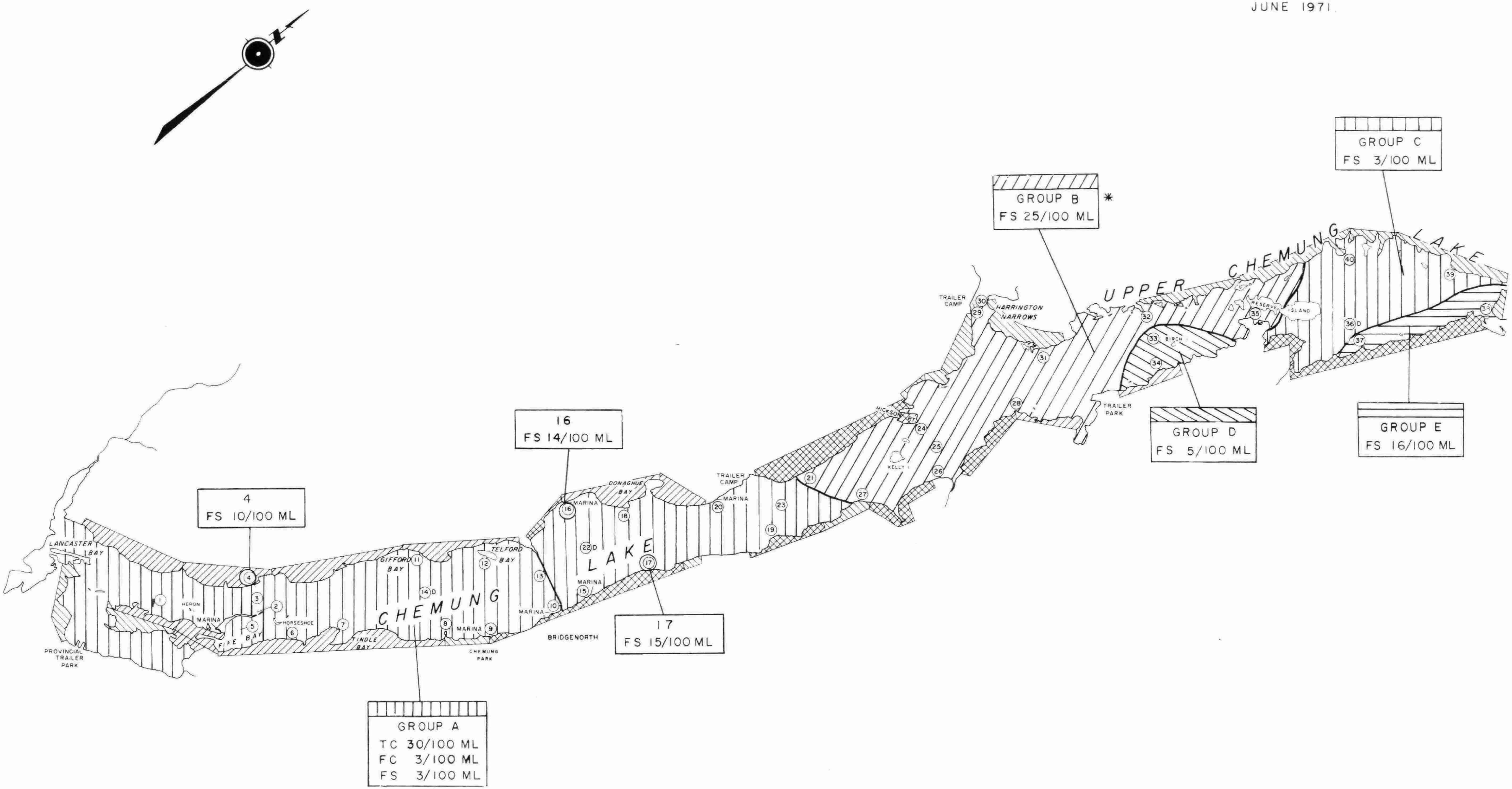
Chemung Lake, was well within the bacteriological criteria for total body contact recreational use (OWRC, 1970) during the three surveys, except for Group B in the June survey which exceeded the FS criteria.

In June, all stations on the lake displayed homogeneously low TC and FC means of 30/100 ml and 3/100 ml respectively (Tables 1 and 2). However, the low TC geometric mean did not adequately represent fluctuations in TC concentrations during this survey. Extremely high background counts were observed throughout the lake after the heavy rains on June 24 (1.24 inches) and June 27 (0.18 inches) recorded at the Trent University Meteorological Station. On June 25, every station either had extremely high TC counts, exceeding 1000 TC or had extremely high background counts which would mask the presence of total coliforms. Due to the antagonistic effect of background colonies, accurate enumeration of Total Coliforms was impossible on June 25; therefore, the overall TC mean in June actually would have been higher than recorded.

In June, the central portion of the lake (Group B) adjacent to Harrington Narrows exceeded the recreational use FS criteria with 25/100 ml (Table 5). Rainfall induced runoff on June 25 yielded very high FS counts at the majority of stations in this group, causing the overall geometric mean to exceed the criteria.

Several isolated shoreline stations (4, 16, 17, Group E) had significantly higher FS means than Group A (Figure 4). The remainder of the lake was divided into three areas, Groups A and C with 3 FS/100 ml and Group D with 5 FS/100 ml (Table 5).

CHEMUNG LAKE
FIGURE —
JUNE 1971



LEGEND

GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML

(17) — BACTERIOLOGICAL STATION

D — DEPTH STATION

* — EXCEED OWRC CRITERIA FOR RECREATIONAL USE

1/2 1/4 0 1 MILE

ONTARIO WATER RESOURCES COMMISSION	
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SCALE: AS SHOWN	
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CHECKED BY: A.M.	DRAWING Nº: 72-32-D.E.A

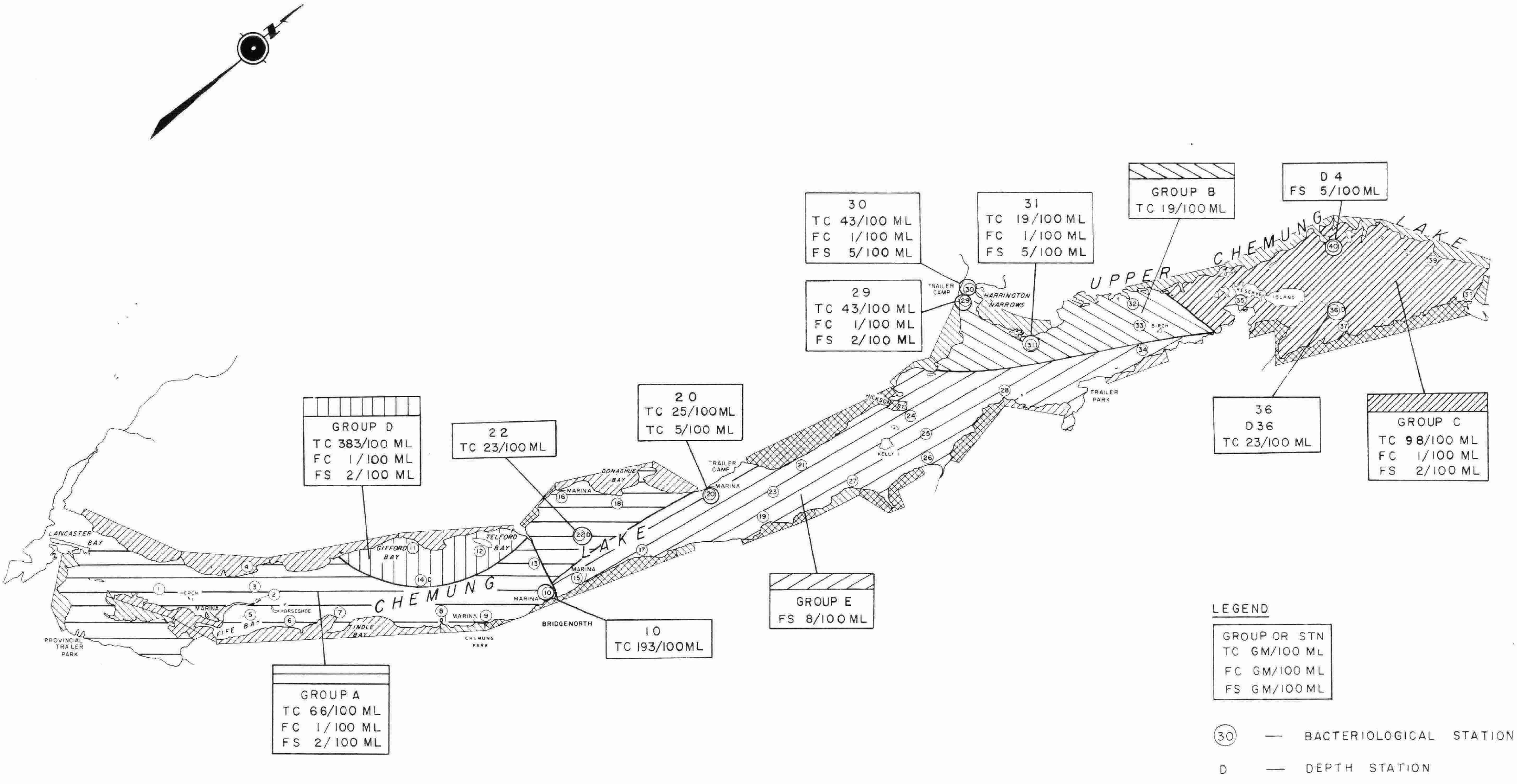
In August (Figure 5), most of the lake yielded overall geometric means of 66 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml (Tables 3, 4 and 5). There were four areas of higher TC densities (Table 3): Group D (383/100 ml), Station 10 (193/100 ml), Group C (98/100 ml) and Group A (66/100 ml); while Stations 20 and 22 as well as Group F exhibited slightly lower TC densities of 25/100 ml, 23/100 ml and 23/100 ml respectively. The central area of the lake (Group B) displayed the lowest TC density of 19/100 ml, with Group E at the outlet exhibiting a significantly higher mean of 43 TC/100 ml (Table 3).

Group G along the east shore from Stations 15 to 31 had the highest FS geometric mean of 8/100 ml (Table 5). This section of the eastern shore is mainly farmland, suggesting that agricultural runoff was responsible for the significantly higher FS mean. Three areas (Group H, Stations 20 and 40) had significantly higher FS means of 5/100 ml.

Runoff from light rainfall on August 10, 11, 12, 15 and 16 caused some daily TC and FS counts to exceed 1000 TC/100 ml and 20 FS/100 ml, especially the TC counts in Group D and the FS counts in Group G.

In September, (Figure 6) all stations displayed homogeneously low TC, FC and FS means of 20/100 ml, 3/100 ml and 3/100 ml respectively, (Tables 3, 4 and 5) with the exception of Stations 14, 26, 33 and 36D. These stations had significantly different TC means of 76/100 ml, 52/100 ml, 6/100 ml and 6/100 ml respectively. Rainfall, previous to the start of the survey, 0.14 inches on September 15, and during the survey, 0.11 inches on

CHEMUNG LAKE
FIGURE – 5
AUGUST 1971.



ONTARIO WATER RESOURCES COMMISSION

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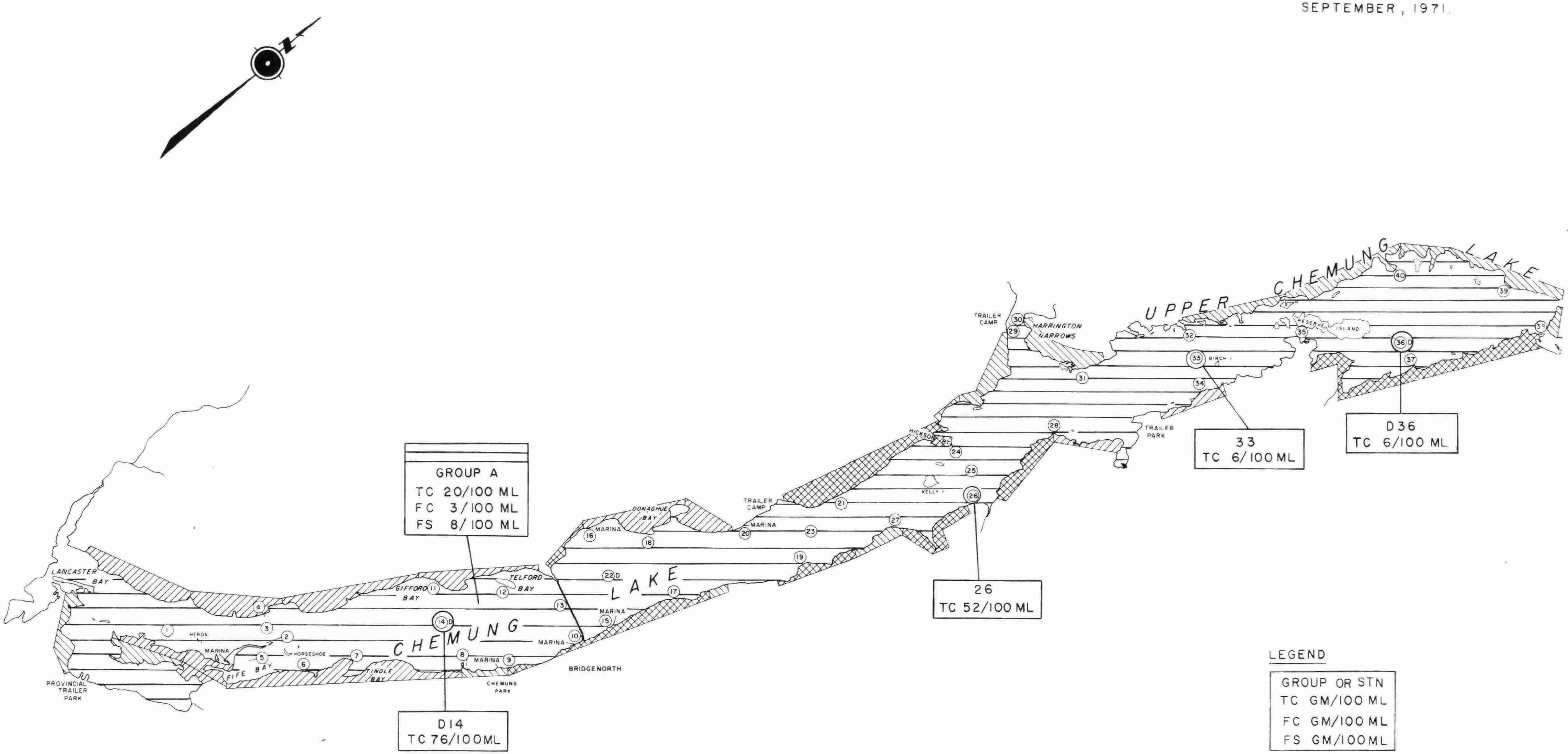
CHEMUNG LAKE
FIGURE - 6
SEPTEMBER, 1971.



LEGEND

GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML

(26) — BACTERIOLOGICAL STATION

D — DEPTH STATION

1/2 1/4 0 1 MILE

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September 16 and 0.27 inches on September 19, was responsible for extremely high TC, FC and FS counts on the days following the rain.

Although Chemung Lake was generally well within the bacteriological criteria for recreational use, no surface water is considered potable without prior treatment including disinfection.

Table 1: Data ranges for temperature, dissolved oxygen, pH, carbon dioxide, total alkalinity, and conductivity for Stations C-1, C-2, C-3 and C-4 on Chemung Lake during 1971.

Station	Sample Depth	Temperature °C	D.O. % Sat.	pH	CO_2 mg/l	Alkalinity mg/l	Conductivity µmhos/cm^3
C-1	1m	14.1-23.5	74-110	7.6-8.3	0.0-3.8	121-148	205-465
	Bottom	14.1-23.2	78- 95	7.7-8.1	1.0-3.6	122-147	205-475
C-2	1m	13.8-24.9	78-110	8.0-8.4	0.0- 3.6	118-135	275-445
	Bottom	13.7-24.1	78-108	7.9-8.5	0.0- 3.9	116-159	255-415
C-3	1m	14.1-24.5	78-115	7.4-8.5	0.0-10.0	124-129	205-405
	Bottom	14.0-22.8	28-103	7.6-8.4	0.0- 7.2	124-134	205-410
C-4	1m	13.7-23.0	73-101	7.8-8.5	0.0- 5.4	115-149	180-490
	Bottom	13.3-23.0	66-101	7.9-8.3	0.0- 4.8	114-148	215-485

TABLE 2: Data ranges for hardness (mg/l), iron (mg/l), total Kjeldahl nitrogen (mg-N/l), total phosphorus (mg-P/l), Chlorophyll a (µg/l) and Secchi disc (m) for Stations C-1, C-2, C-3 and C-4 on Chemung Lake during 1971.

Station	Sample Depth	Hardness mg/l	mg/l	TKN mg N/l	Total-P mg P/l	Chloro a µg/l	Secchi Disc m
C-1	Composite	144-170	0.0-0.15	0.38-0.79	0.016-0.040	0.5-5.8	1.9-5.7
	Bottom	144-172	0.0-0.10	0.36-1.10	0.015-0.074		
C-2	Composite	136-152	0.0-0.10	0.35-0.70	0.012-0.038	1.8-11	1.3-3.9
	Bottom	134-152	0.0-0.09	0.36-0.70	0.014-0.036		
C-3	Composite	144-152	0.0-0.10	0.40-0.80	0.016-0.089	1.2-9.6	1.4-2.2
	Bottom	144-152	0.0-0.10	0.45-0.63	0.008-0.036		
C-4	Composite	136-168	0.0-2.20	0.38-1.00	0.021-0.047	0.6-8.5	1.3-2.6
	Bottom	136-168	0.0-0.22	0.52-0.68	0.024-0.042		

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

TABLE 3

Analysis of Variance Summary of Groups

Parameter - Total Coliform (TC)/100 ml

SURVEY	JUNE	AUGUST	SEPTEMBER
Group	All Stations	All Stations	All Stations
F	0.660	3.337	1.713
df	42, 139	42, 410	35, 142
F(.05)	1.486	1.438	1.713
	NSD	SD	SD
Group	A	A	A
	All stations	Stations 1 to 9, 13, 15 to 19, 21, 23, 26 & 27	All stations except 14, 26, 33 and 36D
F		1.502	1.081
df		19, 198	31, 126
F(.05)		1.84	1.55
		NSD	NSD
Log GM	1.4743	1.8184	1.2901
SE	0.0538	0.0592	0.0329
N	182	209	158
GM	30	66	20
Group		B	
		Stations 24, 25, 28, 31 - 34	
F		1.291	
df		6, 70	
F(.05)		2.25	
		NSD	
Log GM		1.2785	
SE		0.0485	
N		77	
GM		19	
Group		C	
		Stations 35, 37 - 40	
F		1.237	
df		4, 46	
F(.05)		2.61	
		NSD	
Log GM		1.9925	
SE		0.1029	
N		51	
GM		98	

Table 3 - continued

SURVEY	JUNE	AUGUST	SEPTEMBER
Group		D	
		Stations 11, 12, 14, 14D	
F		0.4754	
df		3, 37	
F(.05)		8.59	
		NSD	
Log GM		2.5831	
SE		0.1476	
N		41	
GM		383	
Group		E	
		Stations 29, 30	
t		0.884	
df		20	
t(.05)		2.086	
		NSD	
Log GM		1.6379	
SE		0.1296	
N		22	
GM		43	
Group		F	
		Stations 36, 36D	
t		0.053	
df		18	
t(.05)		2.101	
		NSD	
Log GM		1.3756	
SE		0.1817	
N		20	
GM		23	

Table 4

Analysis of Variance Summary of Groups

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	JUNE	AUGUST	SEPTEMBER
Group	All Stations	All Stations	All Stations
F	1.077	1.137	0.682
df	42, 169	42, 421	35, 141
F(.05)	1.473	1.437	1.518
	NSD	NSD	NSD
Group	A All stations	A All stations	A All stations
F			
df			
F(.05)			
Log GM	0.4282	0.1032	0.4008
SE	0.0344	0.0131	0.0408
N	212	464	177
GM	3	1	3

TABLE 5

Analysis of Variance Summary of Groups

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	JUNE	AUGUST	SEPTEMBER
Group	All Stations	All Stations	All Stations
F	3.811	3.025	0.896
df	42, 170	42, 421	35, 141
F(.05)	1.473	1.437	1.518
	SD	SD	NSD
Group	A	A	A
	All stations except 21, 24 to 40	All stations except 15, 17, 19, 20 - 28, 30, 31 & 34	All stations
F	1.765	1.138	
df	20, 84	30, 304	
F(.05)	1.66	1.46	
	NSD	NSD	
Log GM	0.4242	0.2683	0.4810
SE	0.0462	0.0605	0.0454
N	105	344	177
GM	3	2	3
Group	B	G	
	Stations 21, 24 - 32, 35	Stations 15, 17, 19, 20 - 28, 34	
F	0.524	0.987	
df	10, 44	6, 70	
F(.05)	2.062	3.74	
	NSD	NSD	
Log GM	1.4039	0.8859	
SE	0.0943	0.0681	
N	55	77	
GM	25	8	

Table 5 - continued

SURVEY	JUNE	AUGUST	SEPTEMBER
Group	C	H	
	Stations 36, 36D, 39, 40	Stations 30, 31	
F	1.182	t = 0.134	
df	3, 16	20	
F(.05)	3.24	t(.05) = 2.086	
	NSD	NSD	
Log GM	0.4248	0.7159	
SE	0.1470	0.1895	
N	20	22	
GM	3	5	
Group	D		
	Stations 33, 34		
t	0.421		
df	7		
t(.05)	2.365		
	NSD		
Log GM	0.7016		
SE	0.2005		
N	9		
GM	5		

TABLE 6a

Summary of Tests of Significance Between Analysis of Variance Groups Between Surveys

Parameter - Total Coliform (TC)

SURVEY	JUNE	AUGUST
August	Group A t = 4.717 df = 389 t(.05) = 1.960 SD**	
September	Group A t = 2.826 df = 338 t(.05) = 1.960 SD*	Group A t = 7.152 df = 365 t(.05) = 1.960 SD**

TABLE 6b

Parameter - Fecal Coliform (FC)

SURVEY	JUNE	SEPTEMBER
June		Group A t = 0.517 df = 387 t(.05) = 1.960 NSD
August	Group A t = 10.741 df = 674 t(.05) = 1.960 SD**	Group A t = 9.040 df = 639 t(.05) = 1.960 SD**

TABLE 6c

Parameter - Fecal Streptococcus (FS)

SURVEY	SEPTEMBER
August	Group A t = 2.352 df = 519 t(.05) = 1.960 SD*

GLOSSARY OF TERMS

ALKALINITY
: The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.

ANOXIC
: Refers to conditions when no oxygen is present.

BACKGROUND COLONIES
: Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.

CHLORIDE
: Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.

CHLOROPHYLL a
: A green pigment in plants.

CONDUCTIVITY
: Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.

DIATOMS
: Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.

EPILIMNION
: Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.

EUPHOTIC ZONE
: The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.

EUTROPHIC
: Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

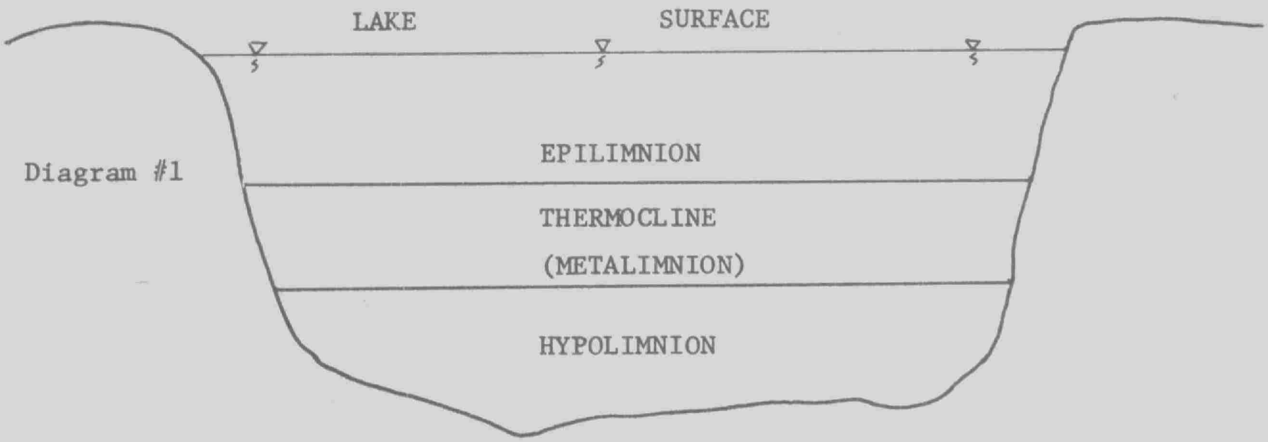
EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC : A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION : During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion) : The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1^{o}C increase per meter.

Diagram #1



TOTAL COLIFORMS (TC) : Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS : Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS (continued)

:oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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Microbiological Criteria
Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

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